What can research on atypical signing tell us about the linguistics of sign language

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Introduction

- The contribution of studies of individuals with impairments in language to our understanding of the brain and its function
- The contribution of studies of individuals with impairments in language to our understanding of linguistics and linguistic theory

The study of dissociations

- Dissociations between impaired and preserved abilities provide key insights into the underlying organisation of language
  - the relationships between language and gesture, iconicity and phonology, verb typology, and visual prosody

Research questions

- Do language impairments lie in a specific modality or are they are modality-independent
- To what extent do the modality and form of a human linguistic system place specific demands on the neural mediation and implementation of language.

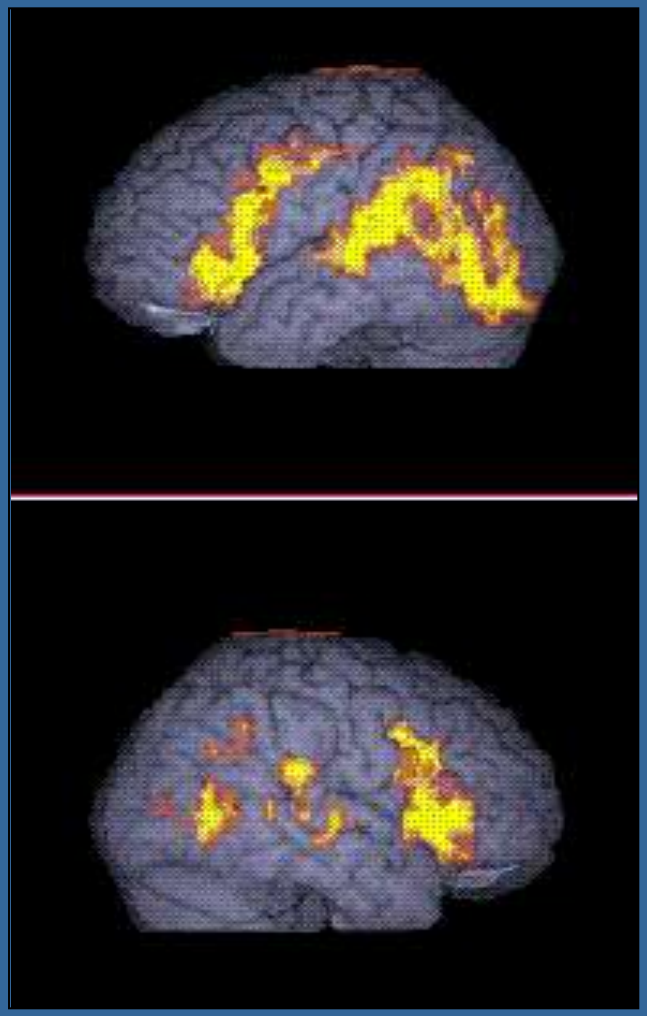
Overview of Talk

- Some of our neuro-imaging studies
- A signer with developmental visual-spatial impairments
- Signers with acquired impairments:
  - Gesture, iconicity and the lexicon
  - Impairments in verb processing
  - Prosody
- Modality-independent and modality-related impairments
  - Implications for linguistic theory
  - Implications for studies of linguistic impairments
- Conclusions

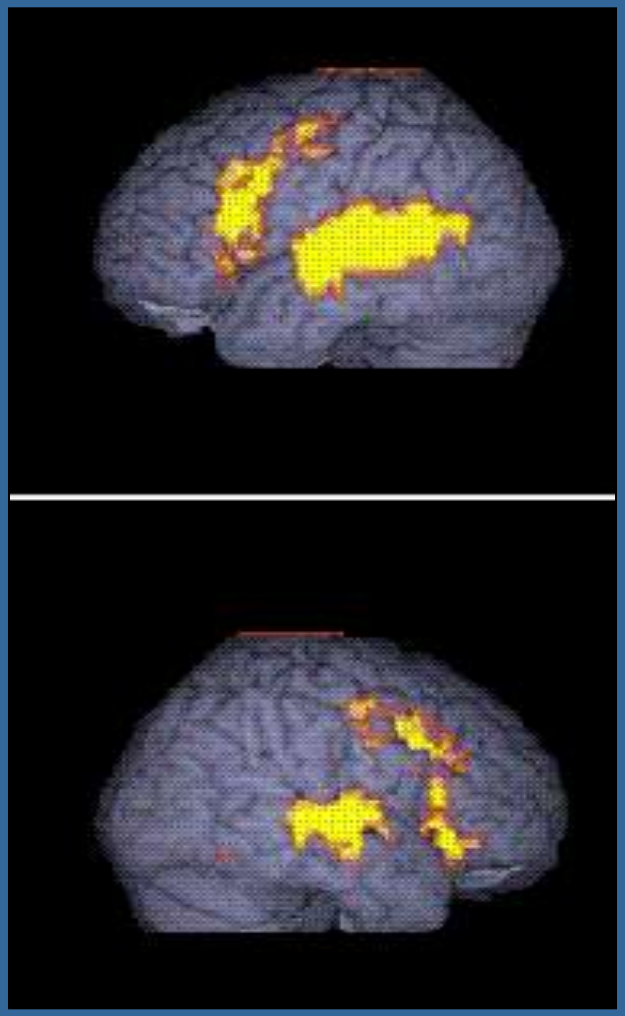
fMRI of BSL – Study 1

- sentence processing – comparing BSL with English
- Deaf native signers and hearing non-signers
- English translations presented audiovisually
  - Coronation Street is much better than Eastenders.
  - I will send you the date and time.
  - The woman handed the boy a cup.
  - Paddington is to the west of Kings Cross

BSL- Deaf native signers



English – hearing native speakers



Results

- Sign language and spoken language both left-lateralised
- More posterior activation during sign language processing than spoken language processing
- Deaf native signers use classical language areas, including secondary auditory cortex, to process BSL

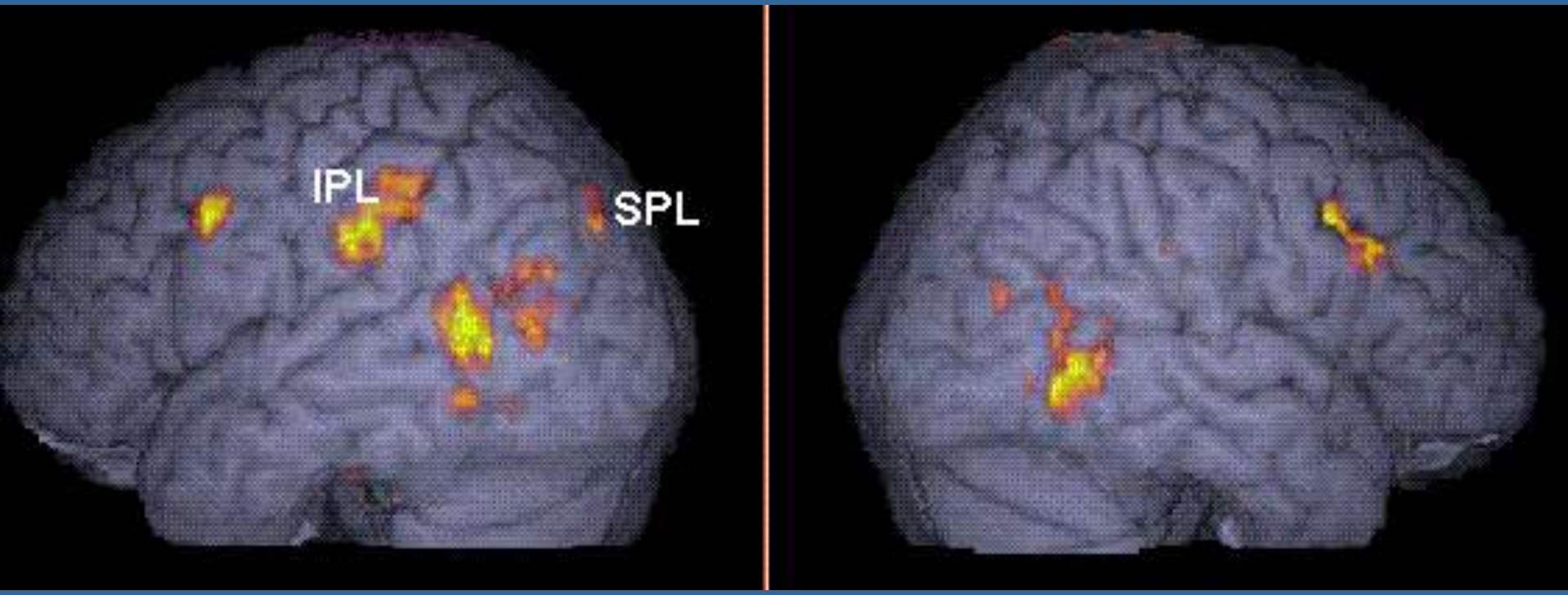
fMRI of BSL – Study 2
using space for grammatical purposes

- comparing topographical and non-topographical sentences
- Same experimental conditions as Study 1
- Non-signers receive audiovisually presented English translations

Results

- The hypothesised right hemisphere processing of spatial constructions was not confirmed
- The processing of topographic constructions in BSL activates left parietal cortex – an area not usually involved in language processing, and not recruited when processing English translations of these sentences.

Processing of topographic sentences



J Cog Neurosci 2002

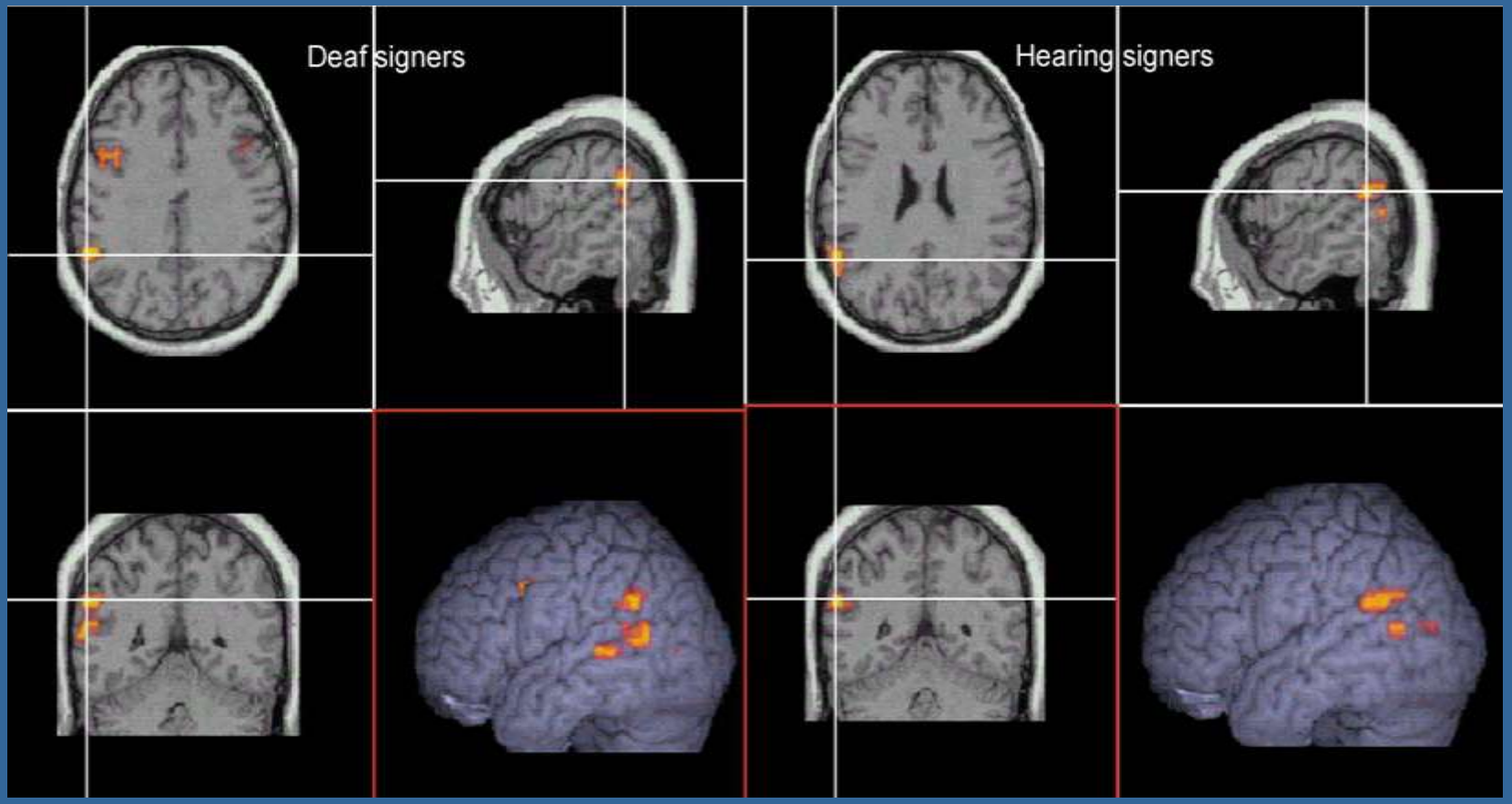
fMRI of BSL – Study 3

Comparing BSL and Gesture

Top: Still images from a Tic Tac sentence.
Bottom: Still images from a BSL sentence

English translation of BSL: ‘This building is being renovated.’

Regions significantly activated more by BSL than Tic Tac in Deaf and hearing signers.



Heather

A developmental case study: a signer with visual-spatial processing impairments

HEATHER

- Aged 34 years
- Short stature
- Unusual facial appearance
- Exuberant social friendliness
- Profoundly Deaf BSL user

Williams Syndrome

Relatively preserved language with marked visual spatial impairment	✓
Preserved face recognition	✓
Unusual facial features	✓
Small stature	✓
Exuberant social friendliness	✓

WS: Interaction between language and VS abilities

- Originally presented as having intact language in the presence of severe visual-spatial impairments – evidence for modularity
- Emerging pattern of strengths and weaknesses across domains. Language not wholly intact. Anomalies in face processing. Shift away from wholly modular processing models.
- Prepositional errors in English (Rubba & Klima 1991) and in Italian (Volterra et al 1994, Capirci et al 1996)

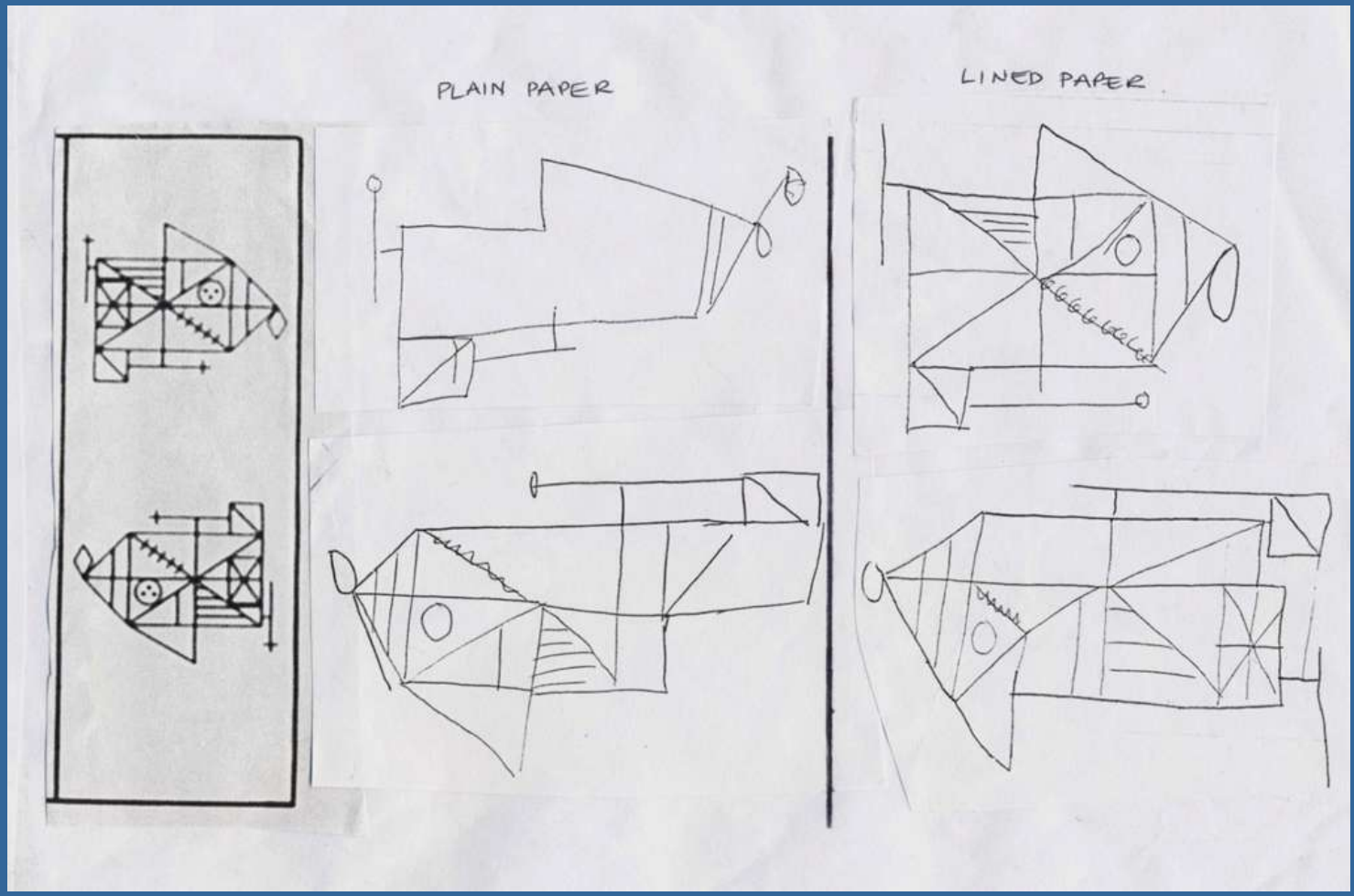
A signer with WS

The possibility of a more transparent interaction between visual-spatial abilities and language

since sign language uses:

- visual-spatial modality
- Spatialised syntax to convey complex grammatical relations
- space in a variety of ways for grammatical functions

Rey–Osterrieth figure



Language Abilities

Vocabulary

- BSL receptive vocabulary 64/68

  Errors all related to spatial concepts

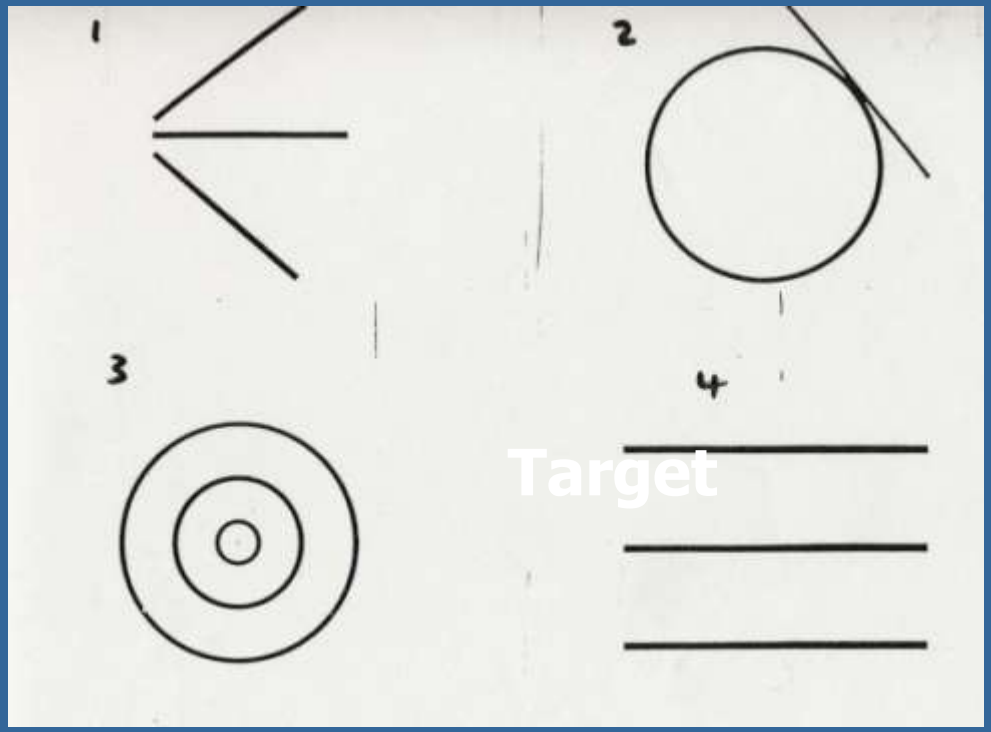
  e.g SHAPE

  PARALLEL

  UNEQUAL

- Test of BSL Noun Comprehension 39/40
- Normal range for (elderly) Deaf controls 38-40

BSL Vocabulary test item ‘PARALLEL’



Production and Comprehension of BSL Grammar

Good command of:

- Noun–verb distinctions
  (BROOM/ SWEEP, MATCH/STRIKE A MATCH)
- Negation (LOLLIPOP NOTHING)
- Plurals (MANY CAR)

Verbs

- 40 examples of BSL sentence*s*
- *Agreement* verbs contrasted with *spatial* verbs
  - The cat chased the dog
  - The woman handed the boy a cup

Verbs

- Comprehension of BSL Verb Agreement = 35/40
  - (elderly) Deaf controls' range = 37-40
- Errors:
  - SPATIAL VERBS
    - Errors in classifiers
    - preference for prepositions (IN, UNDER, ON)

A crossroads with a house at the lower right

CROSS (X) HOUSE CI-'flat object' (lower right)

Target picture

CROSS

HOUSE

CI-'flat object' (lower right)

Observations

- Language > VS abilities
- Subtle impairments found in spoken language in WS replicated and more transparent
- Dissociation between grammar that relies on space, and grammar that can be specified lexically (e.g. plurals, static locatives)
- Dissociation between *spatial* and *agreement verbs*

Explanations?

- Impairments in visual-spatial cognition indirectly impact sign language processing
- Some elements of BSL processing need intact visuospatial cognitive abilities. This is not a language problem, but a cognitive problem
- Reliance of language processing on auxiliary cognitive and output modules

Acquired impairments

Studies of signers with acquired neurological impairments

- LH damage associated with sign language impairment
- RH damage not associated with sign language impairment, even when there are visual-spatial problems

Case study: Charles

Charles

- 55y, right handed male
- previously worked as a leather stitcher
- Hearing parents, but with a deaf brother and deaf nephew
- Preferred language is BSL, acquired age 5
- Left CVA 1999
- Right hemiparesis

General observations

- non fluent – mainly single signs, with virtually no grammatical structure.
- Clear retrieval difficulties, e.g. searches for signs or uses gesture in preference to a sign
- Extensive use of fingerspelling (reported to have been a feature of his communication pre- stroke)
- motoric problems (hesitancy and groping, suggestive of apraxia)
- still often used his right hand as the dominant hand

Tasks

- Sign comprehension and production
- Gesture comprehension and production
- Fingerspelling production

Phonological impairments

Sign-finding errors

- 36/37 in comprehension task
- 27/37 in naming task
- Examples of errors:
  - BANK for MONEY
  - t-o-m for TOMATO, c-h-i-p for POTATO
  - CAR BOX for LORRY
  - Mime of cycling for BICYCLE

Gesture v Sign

- 50 items
  - 25 SLG (sign like gesture) e.g. CIGARETTE
  - 25 SDG (sign different from gesture) e.g. LETTER
- SIGN WHAT? GESTURE WHAT? USE HOW?
- 10 Deaf, 10 hearing controls

Results

	SLG	SDG	TOTAL
Sign score	16/25	9/25	25/50
Gesture score	23/35	18/25	41/50

Signs v gestures: McNemar $\chi^2 = 4.00$, $p < 0.05$
SLG v SDG: $\chi 2 = 4.84$, $p < 0.05$

BUT – scoring of signs is probably too lenient and includes some gestures so effect is likely to be even stronger

Conclusions

- Signs and gestures are processed differently
- Iconicity does not play a part in sign processing. Action schemata may help retrieve gestures but not signs
- Charles has impaired mapping between semantics and phonology: a phonological bottleneck

Patient R.S.

- Problems only with two-handed signs.
  - on signs that require two hands to assume different handshapes and or move independently, R.S. failed to move one of her hands.
  - on signs where one hand moved relative to the position of the other, R.S. might produce an incorrect relational movement
- This case is important for understanding the neurobiology of language: these errors can be taken as evidence for selective form-specific linguistic impairment

RS Conclusions

- Modality may uniquely influence the form of the linguistic deficit → an impairment with no parallels to spoken language disruption
- Availability of two potentially independent articulators may place qualitatively different demands on the on the linguistic system

Acquired impairments: group study

The group study

- 6 patients with RH damage
- 8 patients with LH damage

  (not all participants carry out all tests)
  - 13 born deaf or deafened early in life
  - 1 hearing native signer
- Elderly Deaf controls
  - All use BSL as preferred or first language
- Hearing controls unfamiliar with BSL

	Sex	Age	Hearing status	Time post onset	Neurological information	Hemi-plegia	Age of exposure to BSL	Employ-ment
Stanley	M	68	Born profoundly deaf	6 months	R CVA right parietal lobe infarct	left	5 at school	Painter/ decorator
James	M	42	Born profoundly deaf	18 months	R CVA right middle cerebral artery infarct	left	5 at school	Various manual jobs
Basil	M	62	Hearing (deaf parents)	30 months	R CVA infarct in right internal capsule	left	native	Railway super-visor
Maureen	F	72	Deafened at 18 months	7 months	L CVA in territory of left middle cerebral artery	right	5 years at school	Hair-dresser
Roy	M	62	Born profoundly deaf	7 years	L CVA	right	5 years at school	Factory worker
Henry	M	82	Born profoundly deaf	7 years	L CVA	right	5 years at school	Gardener

Language Tests

Comprehension

1. Test of Lexical Comprehension
2. Test of Verb and Sentence Comprehension
3. Test of Locative Sentences

Production – Naming

Predictions

- LHD group impaired on all tests
- RHD group unimpaired on tests (1) and (2)
- RHD group impaired on test (3)

Test of BSL Lexical Comprehension

Sign to picture matching

- Target
- Semantic distractor
- Phonological distractor
- Visual distractor
- Unrelated distractor

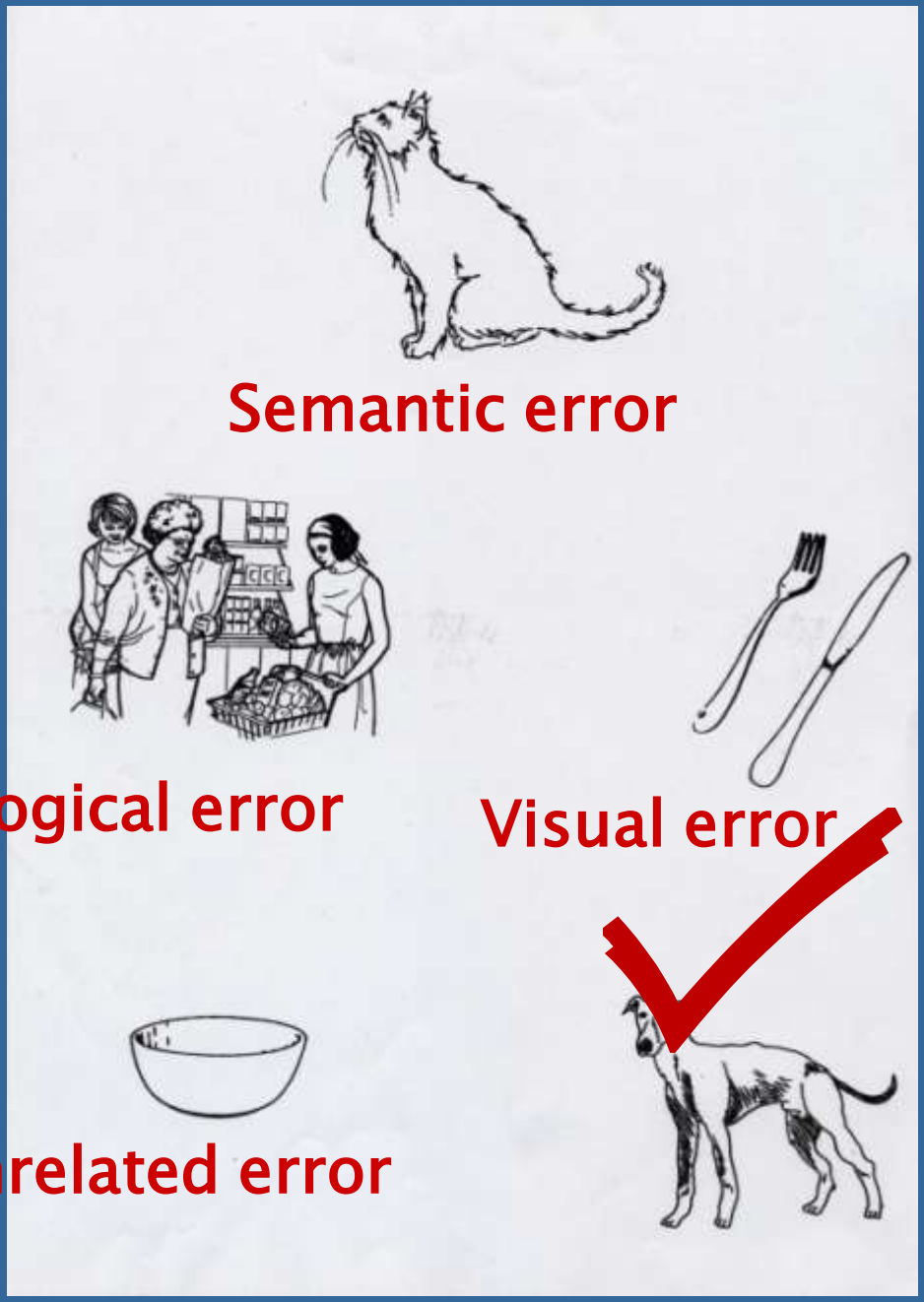
Iconicity

40 items in test

- 20 iconic (e.g. HAMMER)
- 20 non iconic (e.g. DOG)

- Iconicity established by ratings from Deaf signers, hearing signers (interpreters) and hearing non-signers

Noun Comprehension

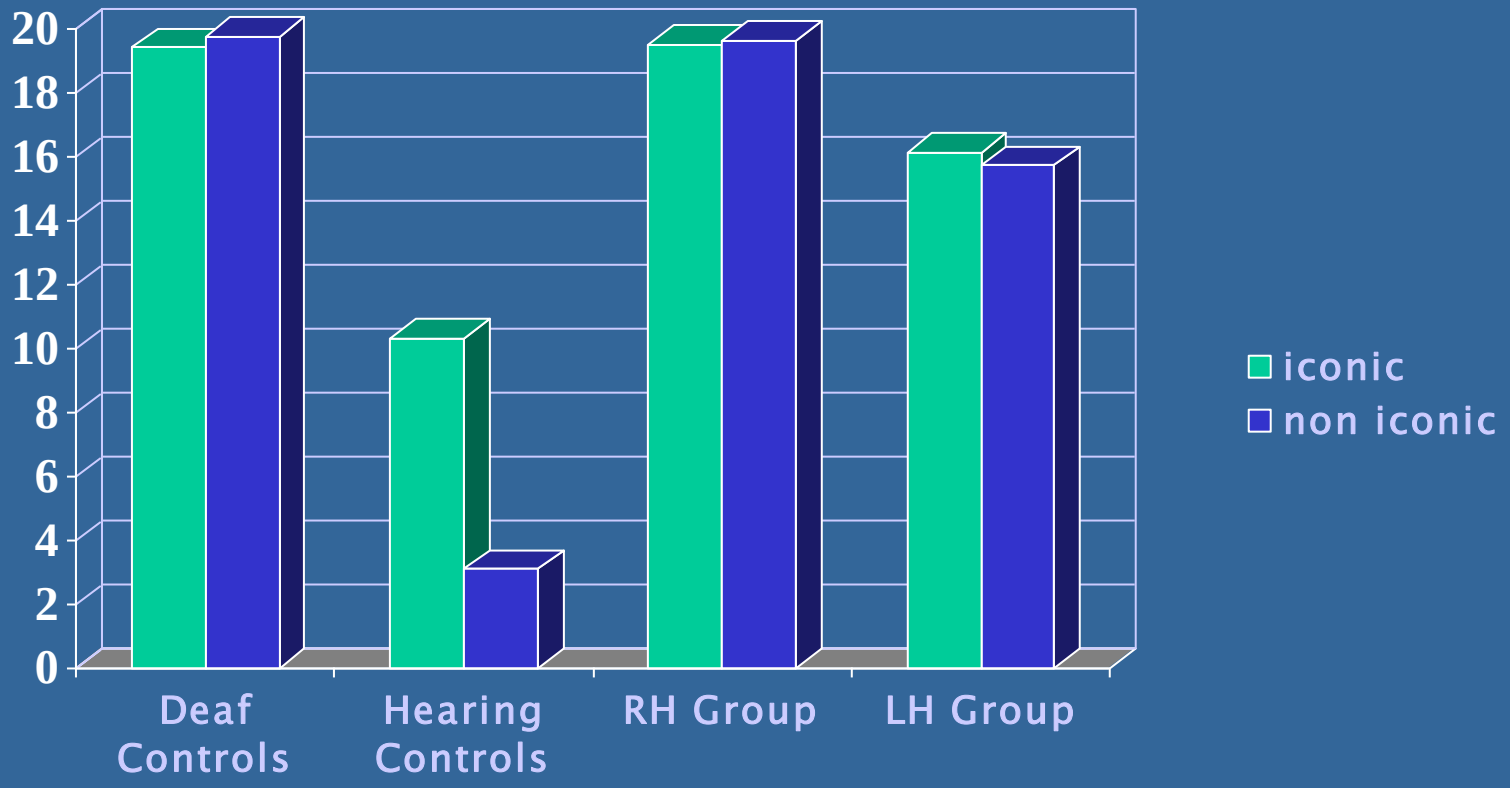


Mean score of elderly controls: 39.2

Iconicity

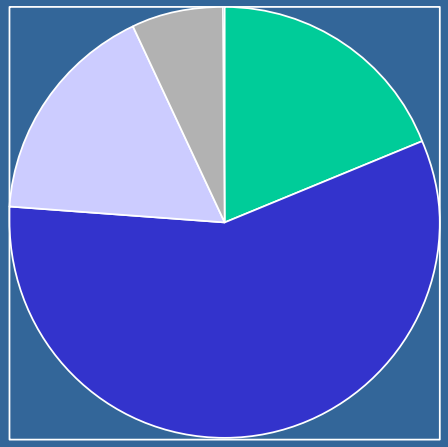
- Hearing controls show a significant effect of iconicity and make mainly visual errors
  - The test is therefore successful at identifying people who are using iconic guess work
- LH group do not show an effect of iconicity
- LH group make mainly semantic, rather than visual errors

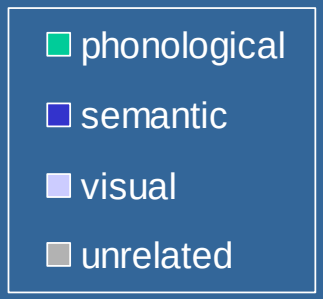
Mean Number Correct on the Sign to Picture Matching Test



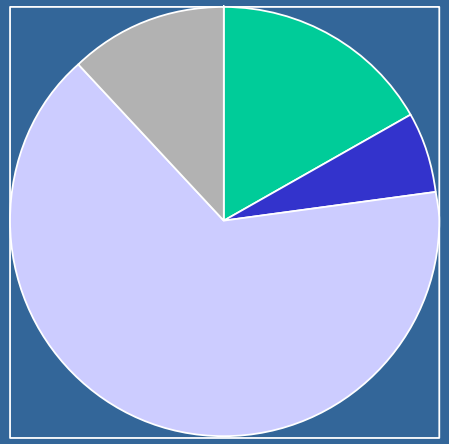
Error Breakdown

LHD Group





Hearing Controls



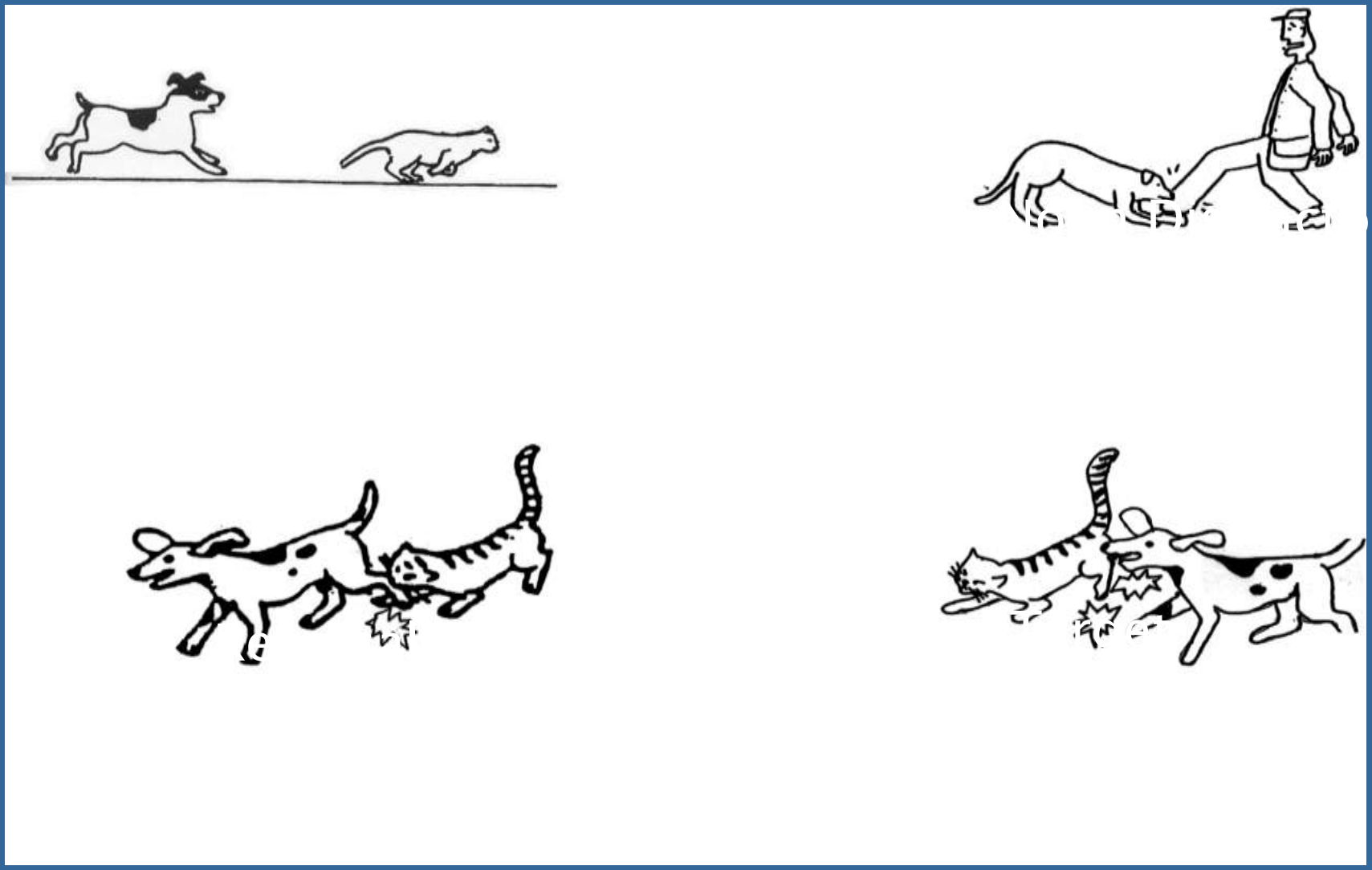
Conclusions

- LH damage impairs lexical comprehension in BSL
- Like hearing people with aphasia, people with sign aphasia make semantic errors in comprehension
- Iconicity does not influence comprehension of BSL signs even in aphasia

Test of BSL Verb and Sentence Comprehension

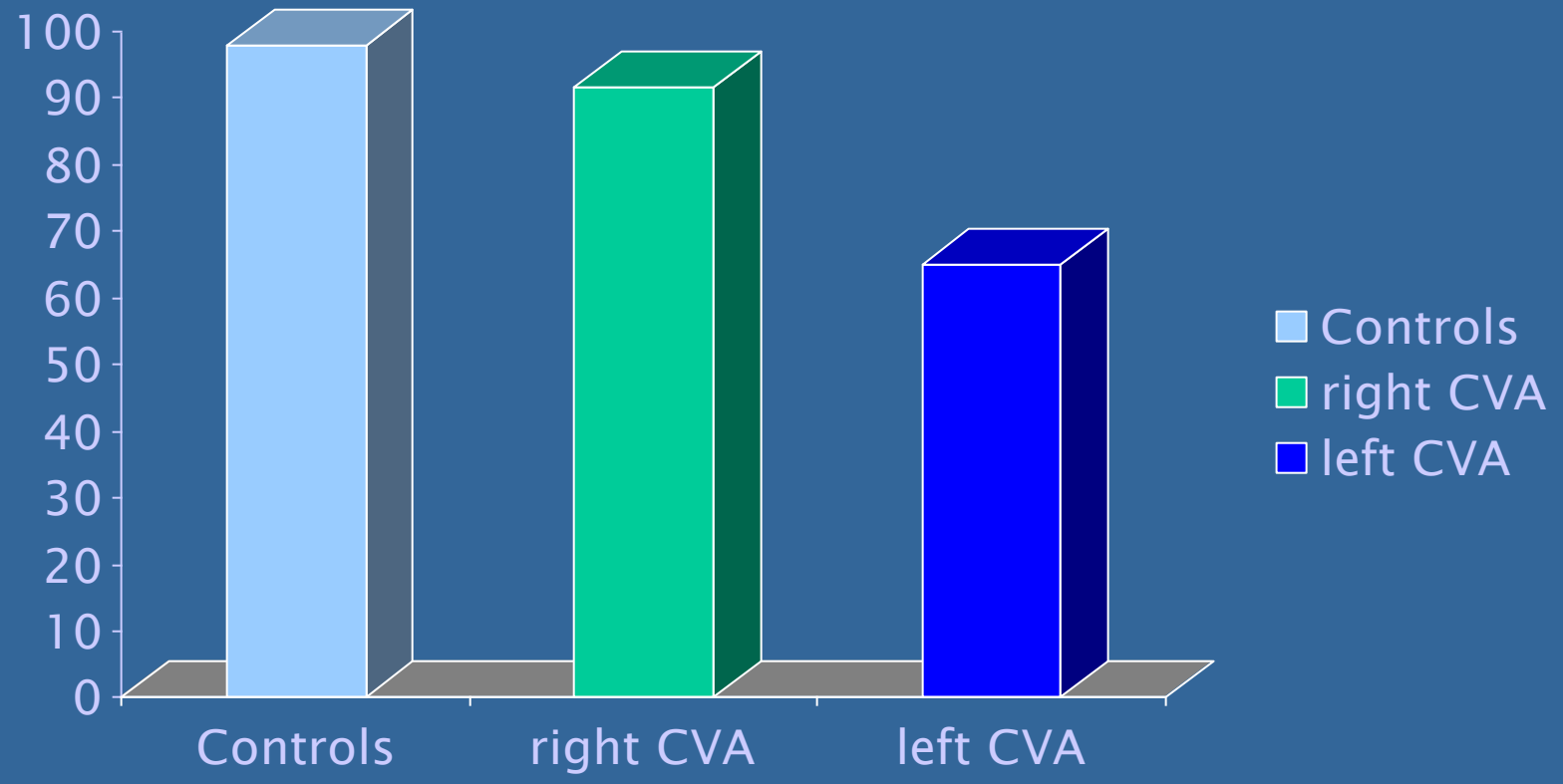
- Examiner signs a verb or sentence
- Matched to one of 4 pictures
- Various types of verbs
- Reversible and non reversible sentences
- Distractors ensure that all the signs and the syntax have to be processed

Sentence Comprehension



Elderly Controls: 97%

Results

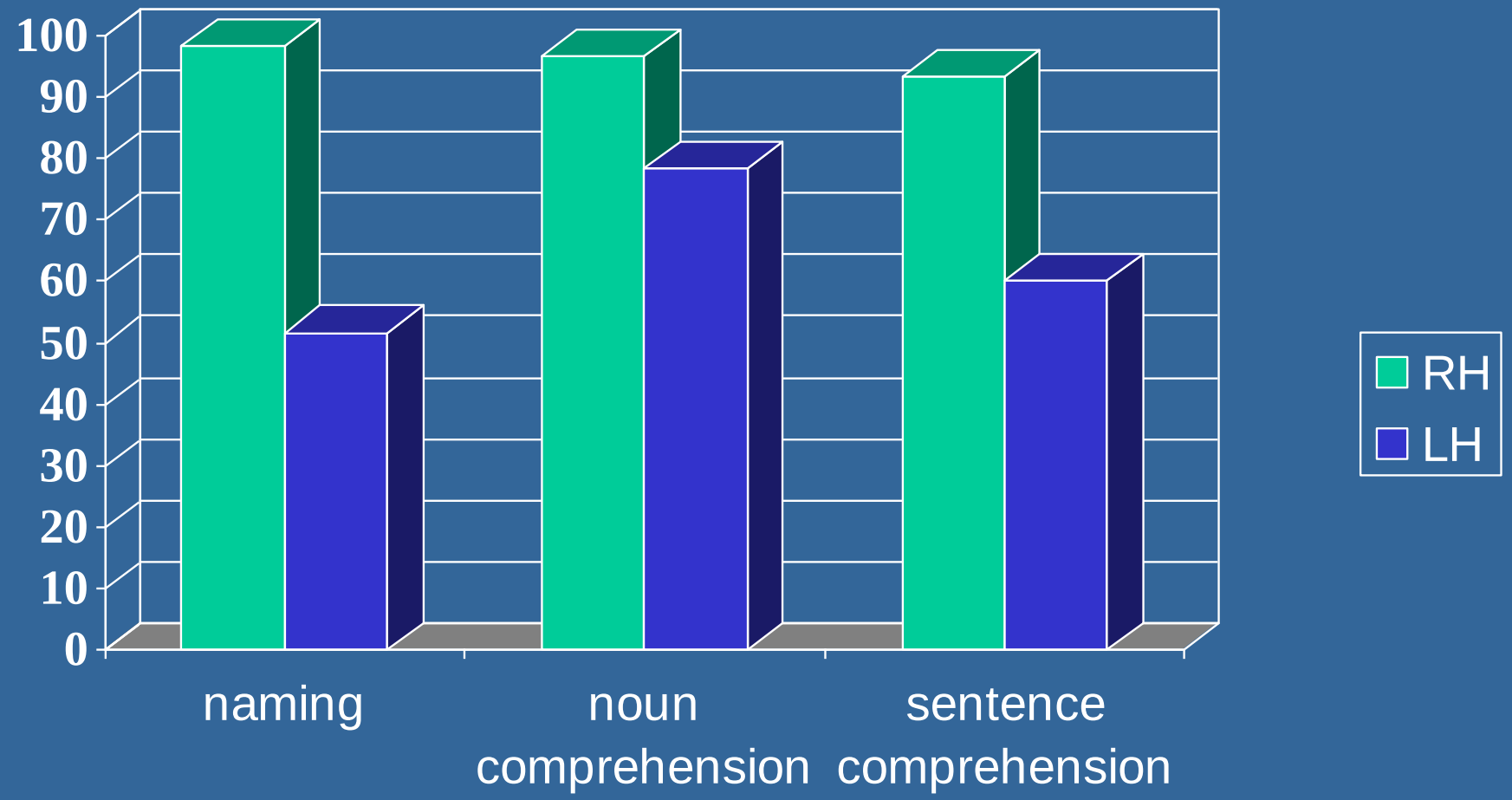

100
90
80
70
60
50
40
30
20
10
0
Controls
right CVA
left CVA
Controls
right CVA
left CVA

Naming Task

What is the sign for this?

20 iconic & 20 non- iconic targets
mean score of elderly controls = 39.4/40

Mean % correct on language tests

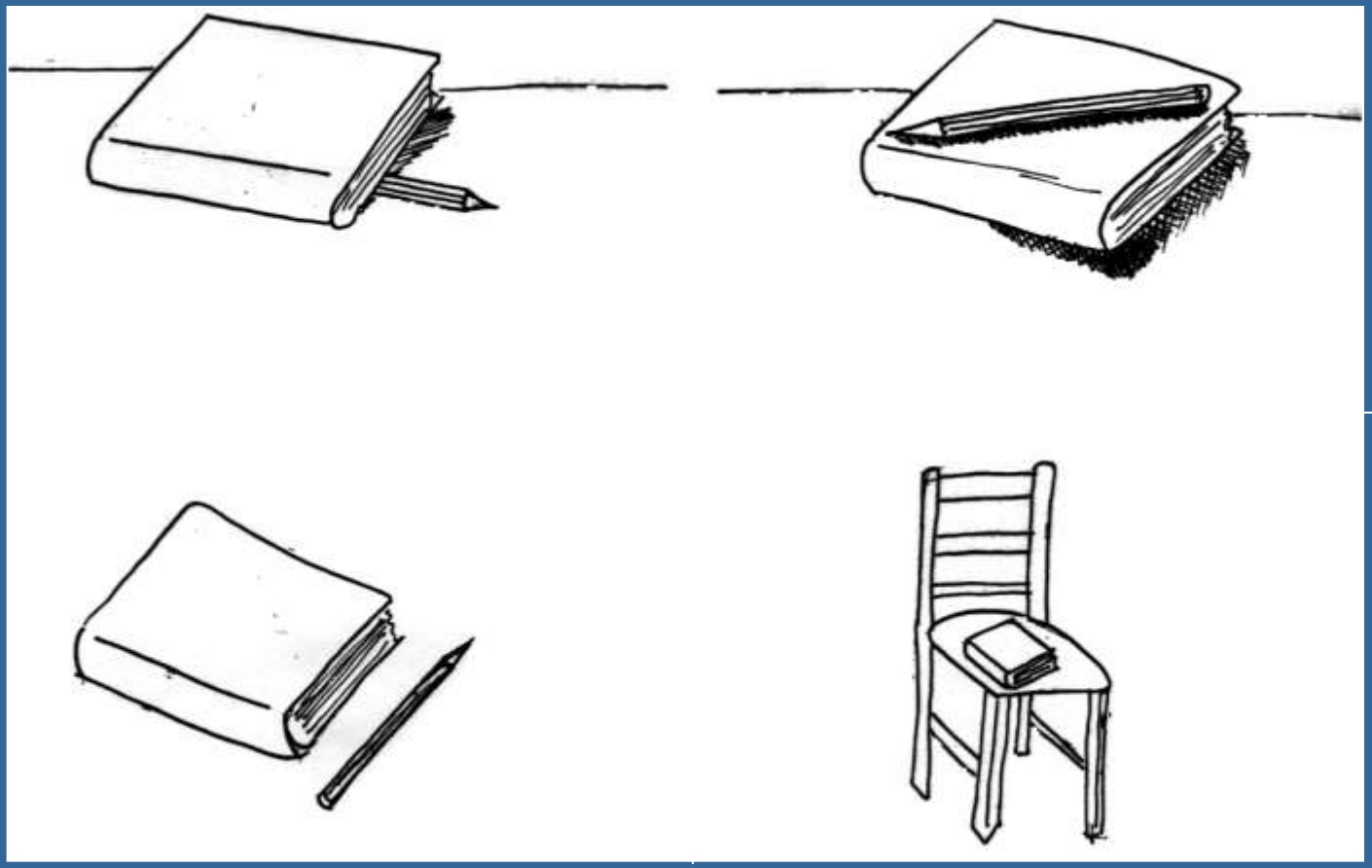


Test of static locative comprehension

- Examiner signs sentence (e.g. BOX CUP ON – the cup is on the box)
- Match to one of 4 pictures
  - Reversal (box on cup)
  - Same objects in different configuration (cup behind box)
  - Different objects (cup on shelf)

- 2 administrations:
  - Using prepositional signs (IN, ON, UNDER)
  - Using classifiers

Test item



The pencil is on the book.

Construction with preposition



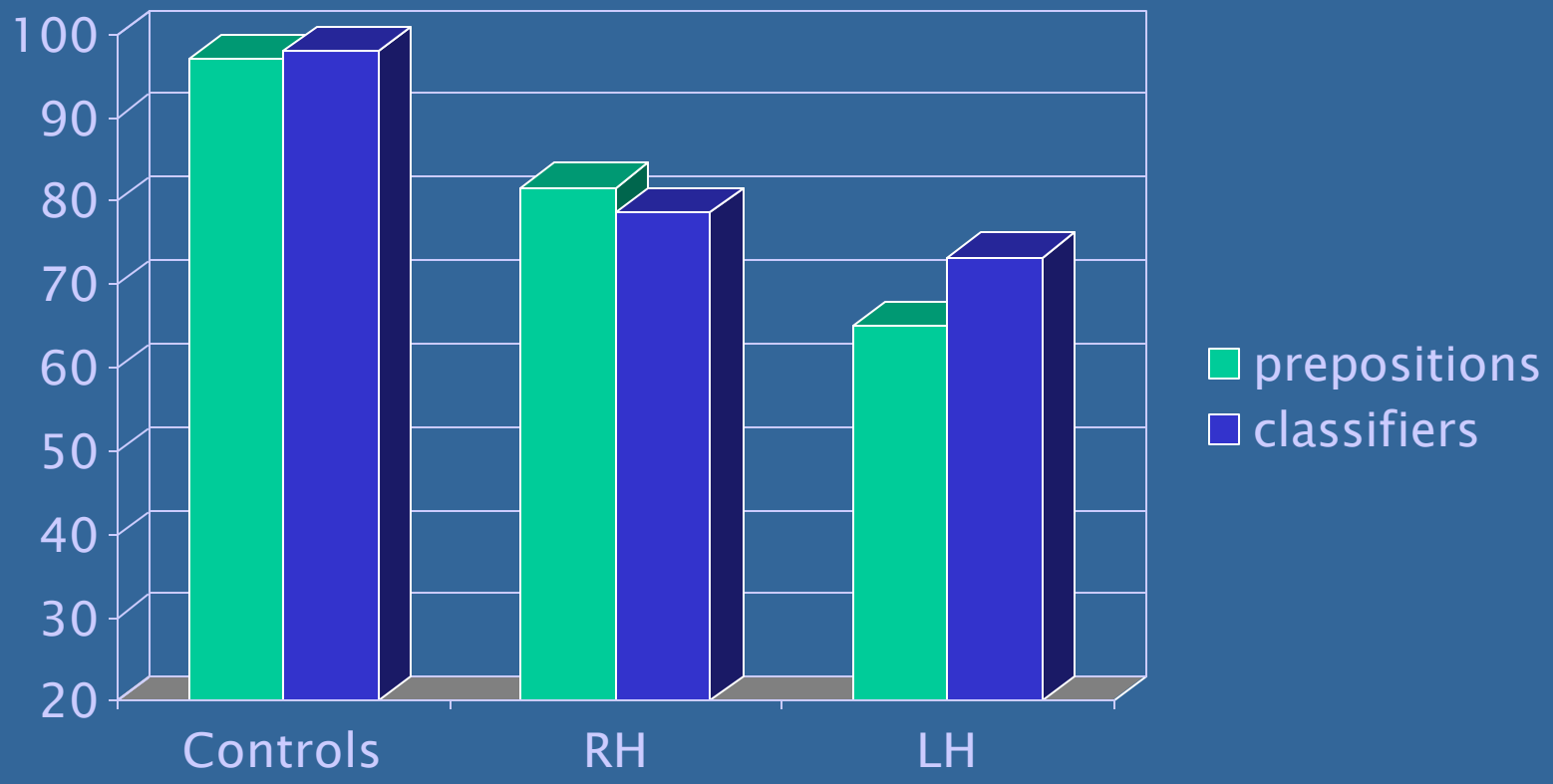
PEN ON PAPER

Construction with classifier



Paper, pen (thin object), thin object on flat object

Mean % Correct on Test of Locative Comprehension



Results

- Deaf controls perform close to ceiling
- People with RH and LH damage are impaired on both versions of the test (although with a different error profile)
- People with RH damage show no effect of administration, i.e. prepositions = classifiers

Implications

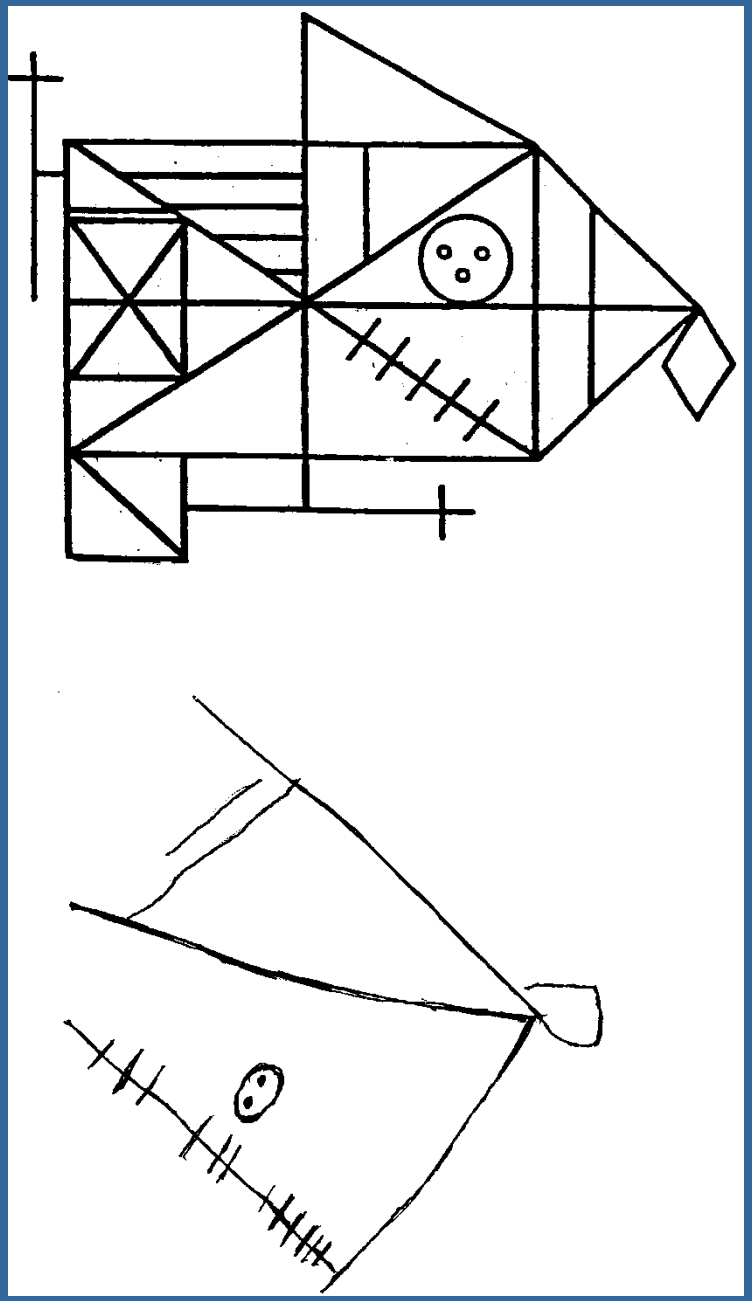
- This is the only test to show RH impairment
- LH patients are worse with the more syntactically complex structures involving classifiers
- RH patients do equally poorly on both tasks: in particular, they are impaired on tests of locative relationships expressed via classifier constructions

Non-manual elements and prosody: role of the right hemisphere?

- Visuo-spatial skills
- Face processing
- Non-manual negation
- Lipreading

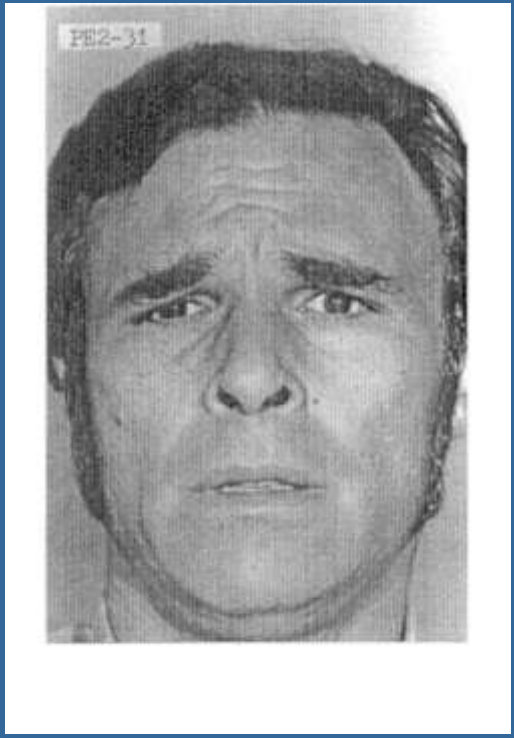
Visuo-spatial Skills: RH patients are impaired

- Drawing
- Line Cancellation
- WAIS – III Block Design
- Ravens Progressive Matrices
- Benton Test of Line Orientation



Tests of Face Processing

- All RH participants are impaired on all tests



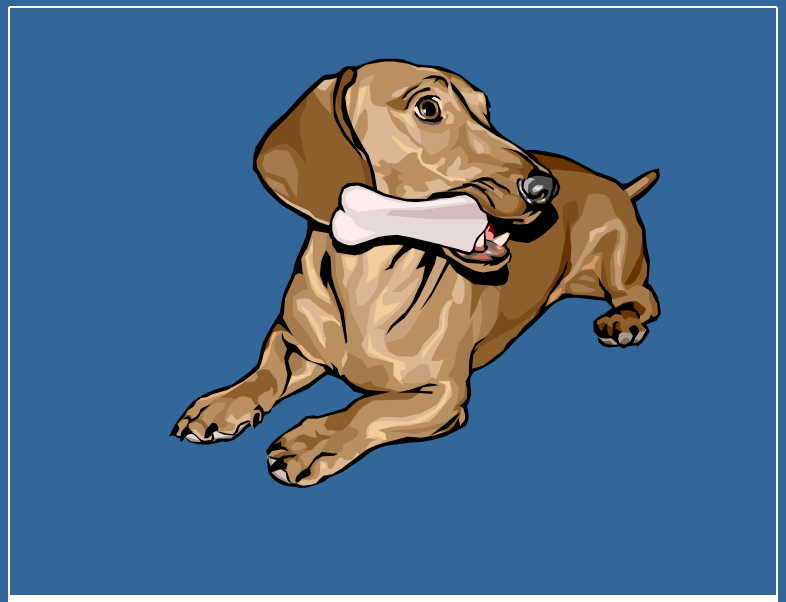
Stanley: HAPPY
Brian: NONCHALANT

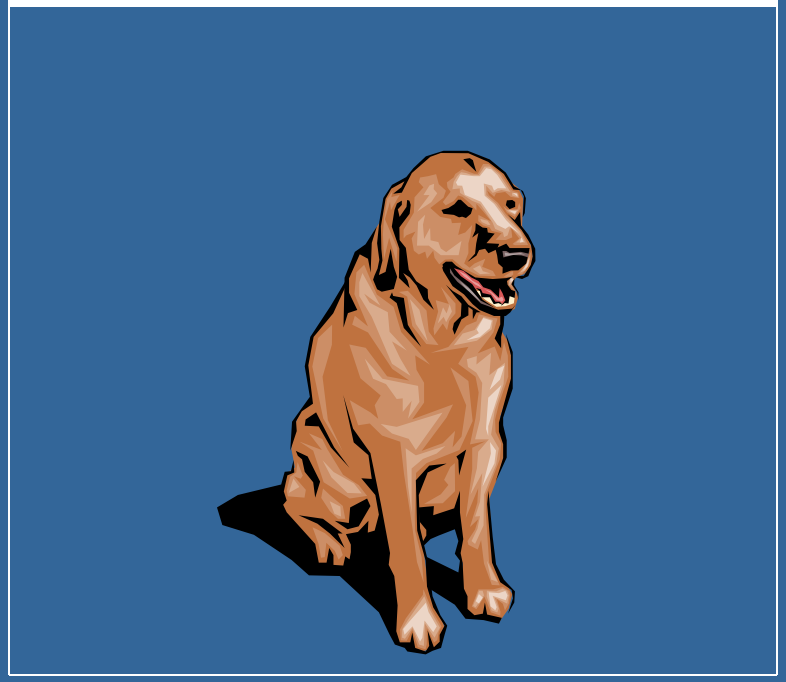
Test of Negative Comprehension in BSL

- Negation in BSL:
  - manual (NOTHING) + face
  - face alone
- Hypothesis:

  LH: manual + face = face alone

  RH: manual + face > face alone





Presentation A:

BONE (HAVE)

Presentation B:

BONE NOTHING

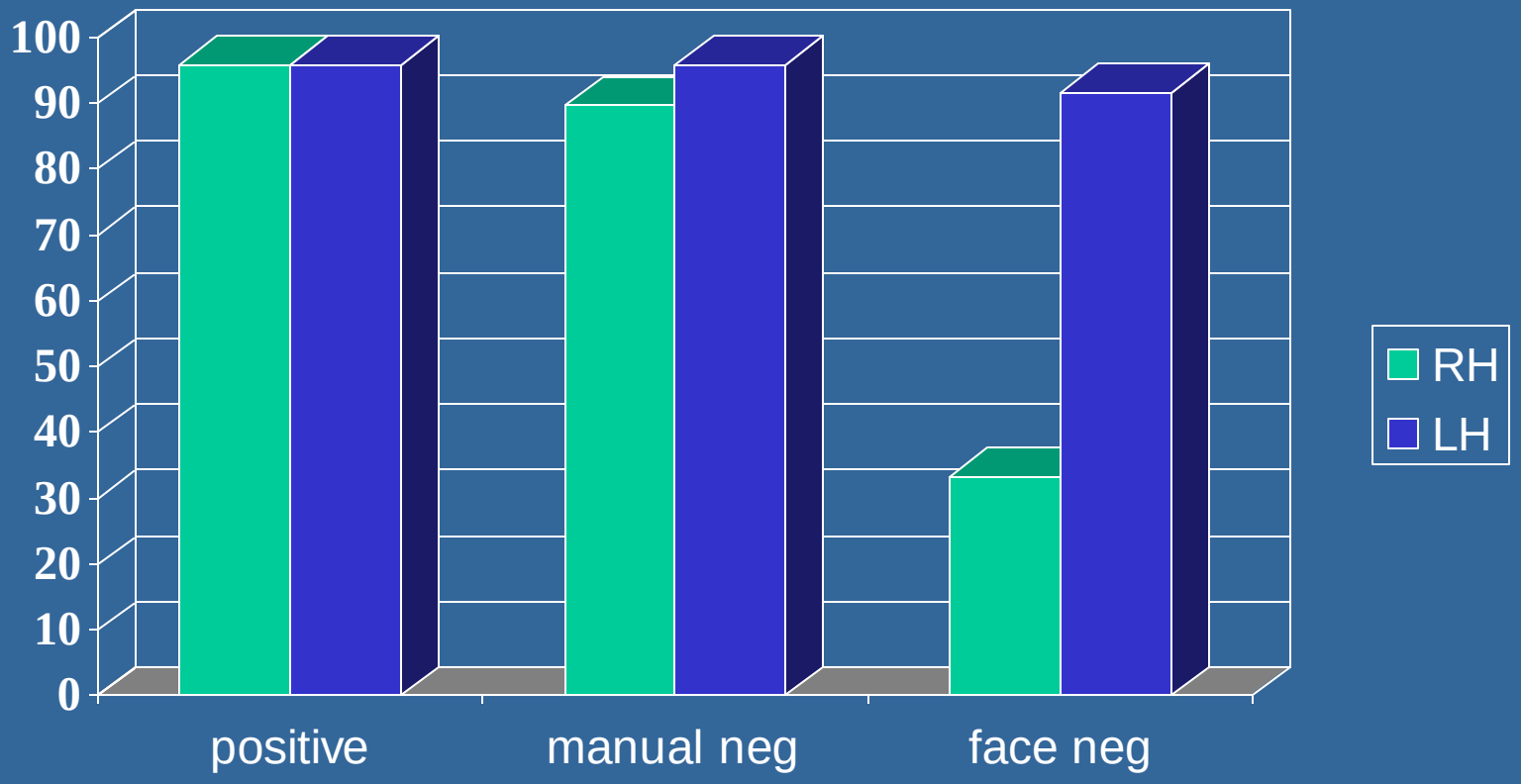
(manual + face)

Presentation C:

BONE (NO)

(face alone)

Results: Mean % Correct



Results from Test of Negative Comprehension

- LH virtually at ceiling on test
- RH impaired, but only when negation is expressed with face alone

- Do RH face processing impairments affect perception of all information on the face?

4. Lipreading tasks

Task 1: lipreading numbers

- Subject watches the examiner say the numbers 1 – 10 without voice and in random order. S/he has to point to the corresponding digit on a printed response card.

Task 2: lipreading proper names

- Subject watches the examiner say 10 proper names without voice: e.g. Bob, Arthur, Ellen, Amy. S/he has to point to it on a printed response card.

All RH patients made ≤2/40 errors per task

Summary (1)

- LH damaged BSL signers, relative to elderly control subjects, exhibit deficits on all comprehension tests.
- Right hemisphere damaged signers do not differ from controls on single sign and single predicate-verb construction, or on sentences that range in argument structure and semantic reversibility

Summary (2)

- Participants with LH damage are impaired on language tests
- Iconicity does not affect sign production or comprehension in aphasia
- Gestures, even when similar in form to signs, are processed differently

Summary (3)

- Participants with RH damage perform within the normal range on language tests
  - None displays aphasia in general conversation
- RH damaged signers do not differ from controls on single sign and single predicate-verb construction, or on sentences that range in argument structure and semantic reversibility

Summary (4)

- RH patients' problems may be a consequence of more general visuo-spatial impairments, since they are as impaired on prepositions as on classifiers
- LH patients are worse on prepositions.
  - Non-linguistic visuo-spatial skills may assist them to process classifiers **OR**
  - Classifier constructions may make fewer demands on short-term memory

Summary (5)

- Sign language can withstand facial processing impairments arising from right hemisphere damage
  - Lexical and syntactic processing are largely unaffected
  - But some non-manual features are affected
- Right hemisphere is associated with prosody, so we need to examine the prosodic status of non-manual negation

Implications for understanding neurolinguistics of SLs

- Several studies have found differential disruptions in the use and comprehension of sentences that involve usage of classifiers

Interpretations

- Comprehension of classifier constructions requires not only intact left hemisphere resources, but intact right hemisphere visual-spatial processing mechanisms as well.
- While both LHD and RHD signers show comprehension deficits, the RHD signers' difficulties may stem from different causes: general visual spatial deficits rather than linguistic malfunction per se.

- Should aphasic deficits be solely defined as those that have clear homologies to those in spoken languages, or does the existence of sign languages force us to reconsider the concept of linguistic deficits?

Final thoughts

- Studies of sign language impairments are not only interesting in themselves but provide a critical test bed for theories of language and language processing